# Stockbridge Underwater Robotics Team 1

Stockbridge High School - Stockbridge, MI 49285

*Picture taken by Skeeter Ballagh*

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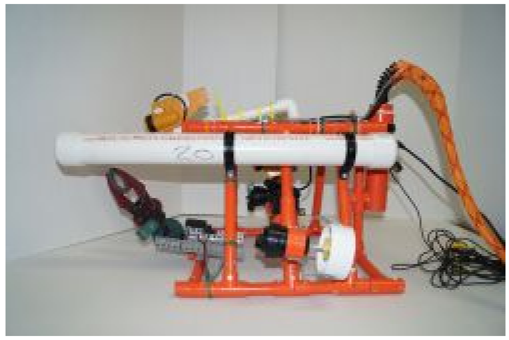
**Rebecca Ensign-** Junior, 1st year member, co-marketing leader, tether operator.

**Andrew Best-** Sophomore, 1st year member, co-pilot.

**Robert Richards-** Instructor/mentor.



**Side View of ROV-** In this picture, you can see the side view of the claw, ballast, tether, and propellers.

*Picture taken by Chloe Hypes*

**Top View of ROV-** This picture contains the top view of all four propellers, the claw, two ballasts, tether, and the top camera.

*Picture taken by Chloe Hypes*

**<u>Front View of ROV-</u>** In this picture you can see the claw, camera #1, and the front view of the propellers.

*<u>*Picture taken by Chloe Hypes</u>*

**<u>Back View of ROV-</u>** In this picture you can see the back camera and the back view of the propellers.

*<u>*Picture taken by Chloe Hypes</u>*

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# Abstract

The Stockbridge Underwater Robotics Team 1's main focus as a company is to provide an effectively working ROV that can efficiently explore lake floors to provide every need for each one of our clients. Our team is composed of five Stockbridge High School students with expertise in engineering and marketing. As a company, we aim to create new ways to solve real world situations using underwater robots. When posed with the challenges of the competition, we came together as a team to discuss our design. The design incorporated two payload tools, a vertically mounted claw, and a syringe to suck up agar. Our ROV features three cameras, so we can view a shipwreck at any angle. We built shrouds to go around our propellers for safety reasons. The propellers are run by the thrusters, or motors. Ballasts were added to help with buoyancy issues, while a conductivity sensor was added to test the conductivity of the water. All of these features allow us to successfully complete mission tasks or explore lake floors. As a company, we have tried to add on as many features as we could to help our client in every way possible. As of now, we plan on diving lakes around our area, and we hope to soon venture into the ocean to explore the wonders of the oceanic floor.

Acknowledgements...............
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# Expense Sheet

| Item | Funds | Price |
|---|---|---|
| SeaMATE Controller | Self-Funded | $325.00 |
| TriggerFish Controller | Grant Funded from NSF and MATE Center | $600.00 |
| TechFlex | Self-Funded | $227.00 |
| Shrouds | Self-Funded | $52.00 |
| 3 Harbor Freight Fish Finder Cameras | Self-Funded | $483.00 |
| 10ft of 2 inch PVC Pipe | Classroom Stock | $7.45 |
| 10ft of 1 inch PVC Pipe | Classroom Stock | $3.78 |
| 2 Wire Motors with Motor Controller | Self-Funded | $100.00 |
| Screws | Self-Funded | $3.78 |
| Zip Ties | Self-Funded | $3.00 |
| U-Clamps | Self-Funded | $13.08 |
| Plastic Bin | Self-Funded | $9.41 |

| | | |
|---|---|---|
| Garden Hose Spool | Self-Funded | $11.65 |
| Chelsea Pool Time | Donated | $75.00 |

**TOTAL: $1,914 .15**

**Highlighted- Donations**

# System Interconnection Diagram

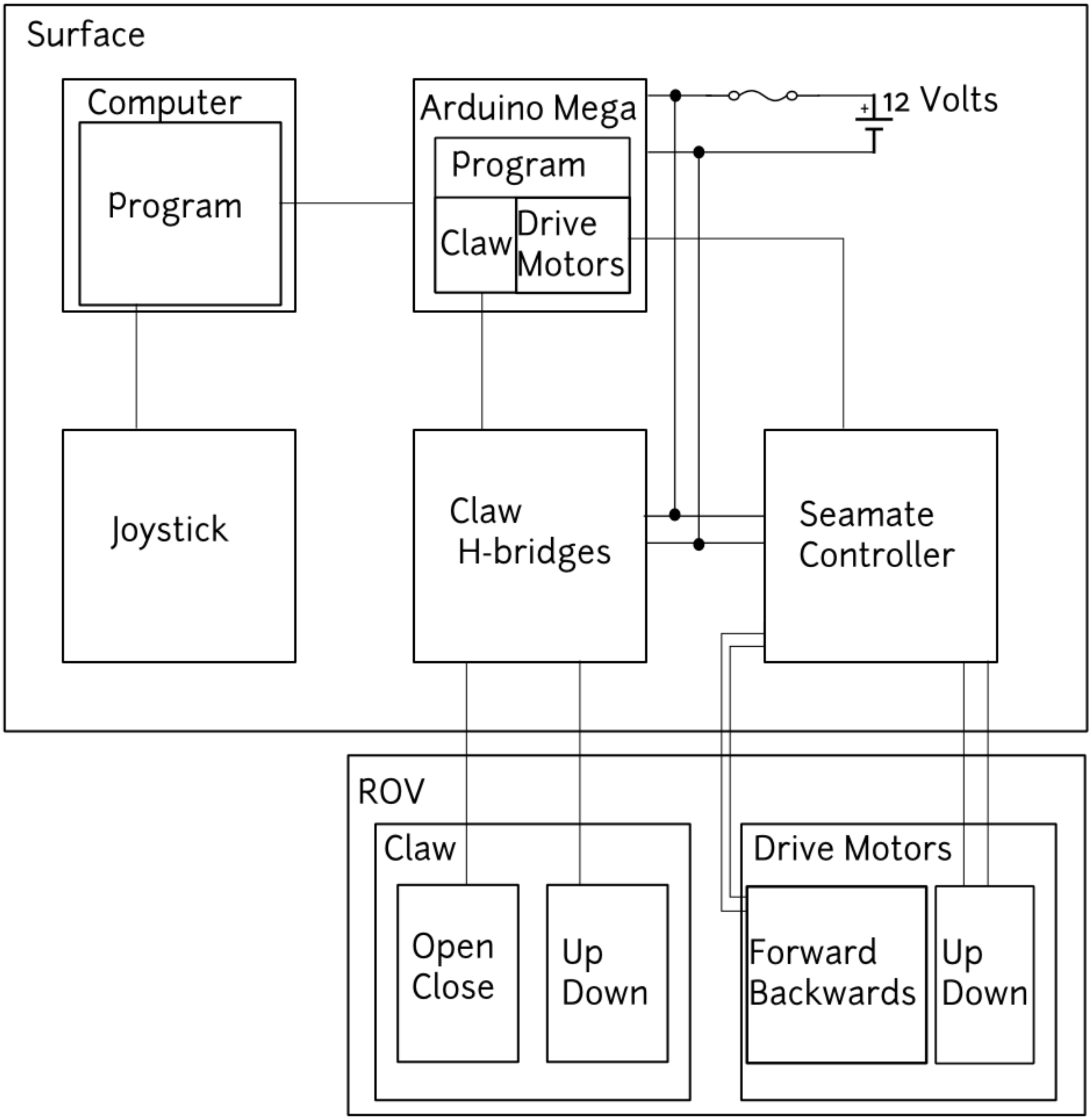


*Diagram by Philip McCleer*

This diagram shows how the land and ROV side of everything is connected. Each line interconnecting the different blocks represents the wires in that connection. Since the up/down and forward/reverse directions are each controlled by two motors, they get two lines for each motor pair. This diagram also shows the location of the programs and their role in successful operation of the vehicle.

# Flow Charts

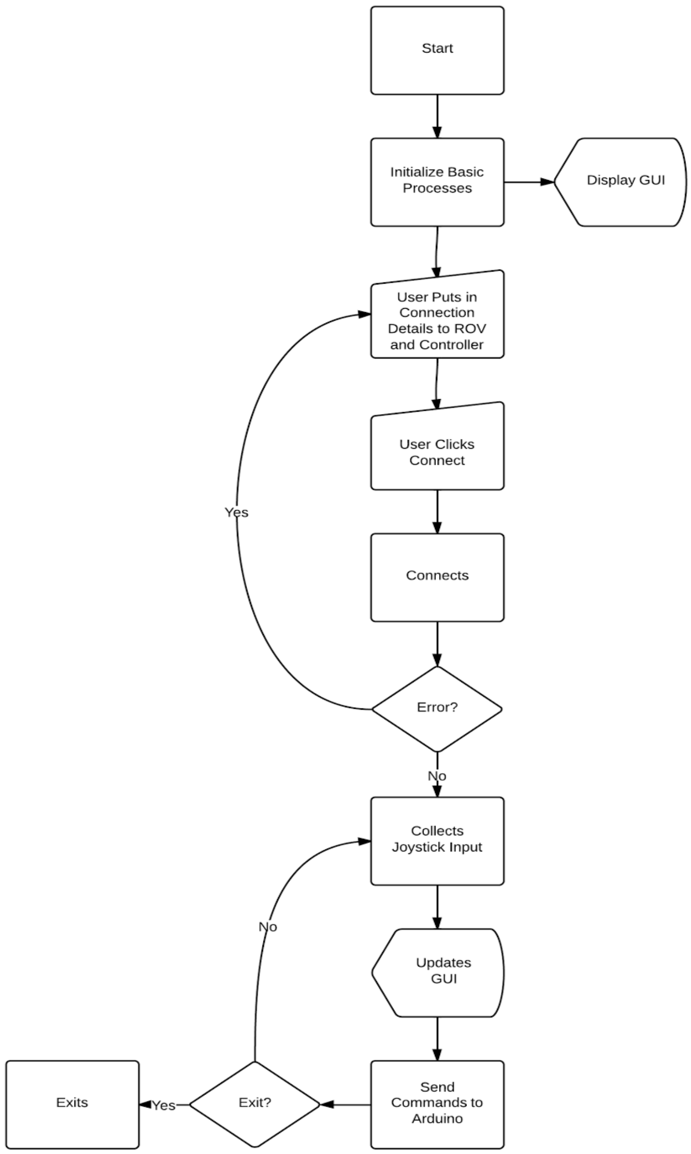


*Diagram by Philip McCleer*

This shows a simplified version of our computer run program. Due to the complexities of most GUI systems, our company decided to omit that portion for more universal understanding.

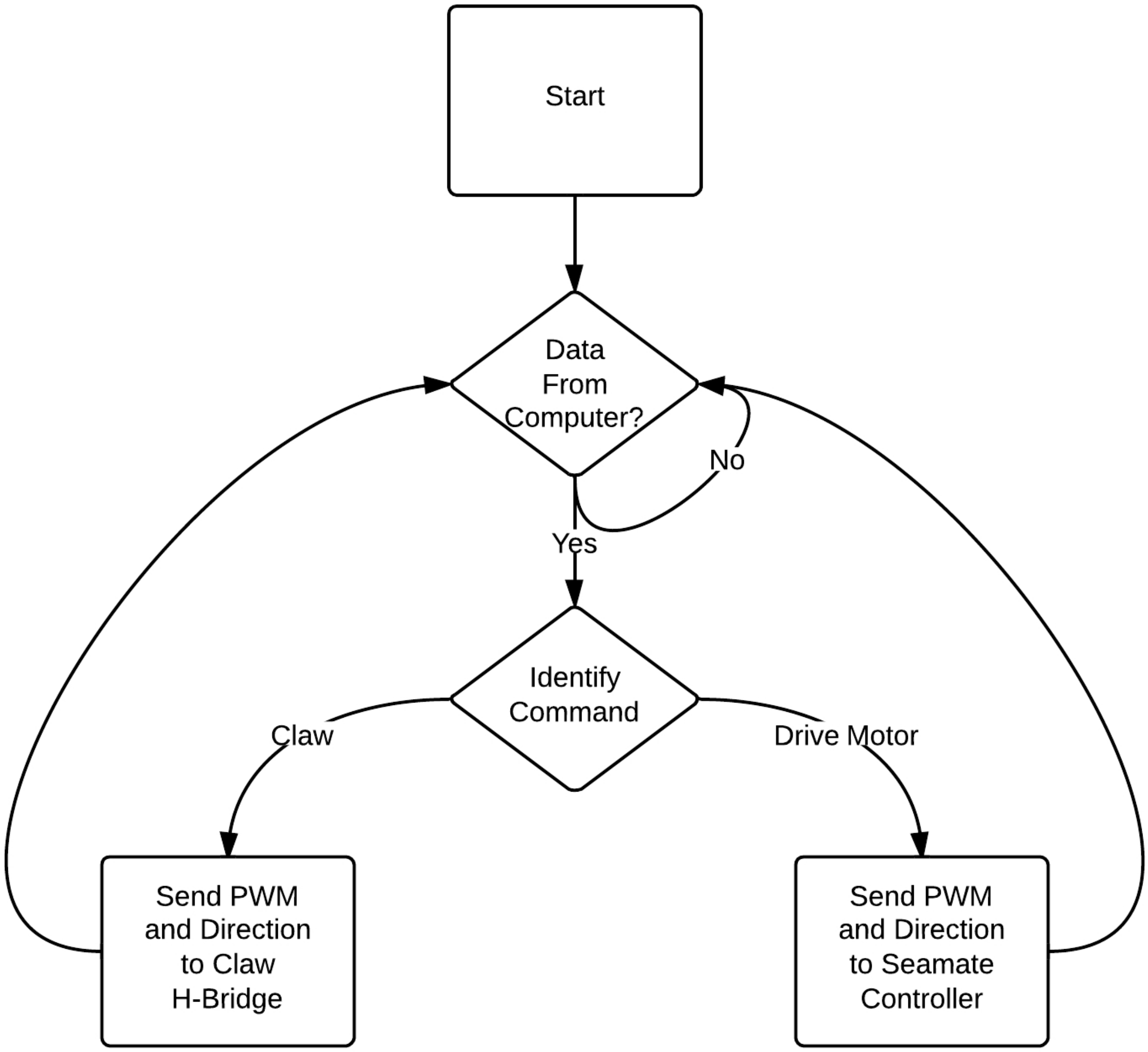


*Diagram by Philip McCleer*

This shows what the Arduino Mega does after it is turned on. We have found it unnecessary to store and send the last received signal over and over again due to our regular update schedule.

# CAD Drawings

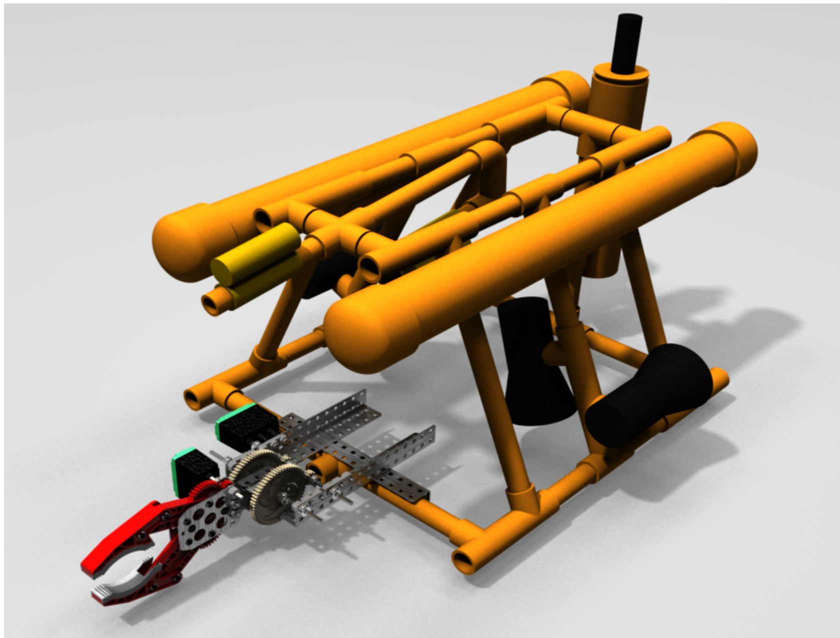

*Diagram by Philip McCleer

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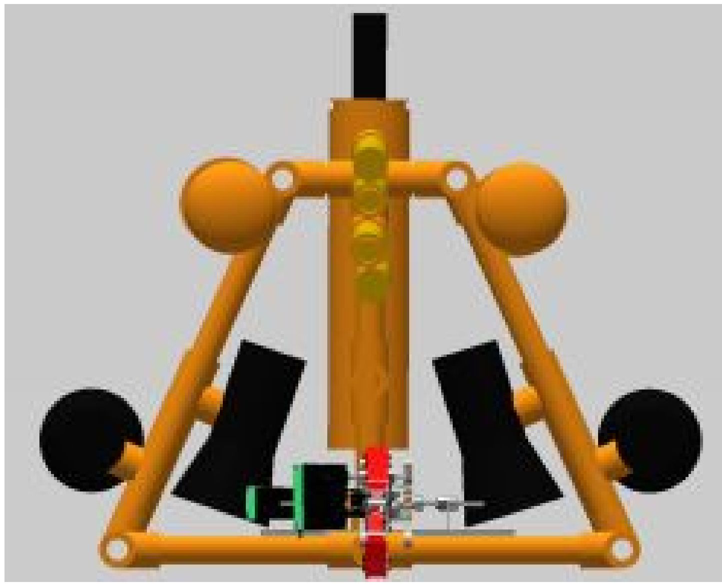


*Diagram by Philip McCleer

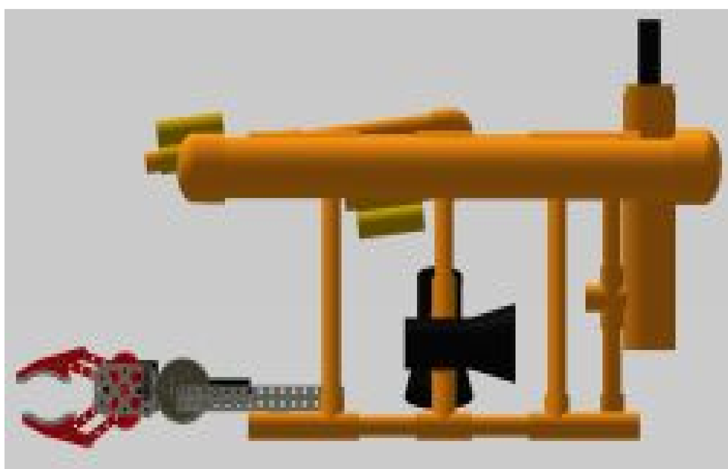
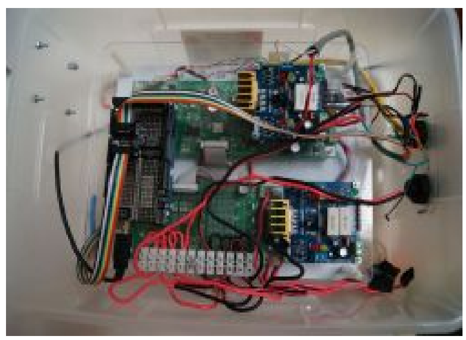


*Diagram by Philip McCleer

# Design Rationale

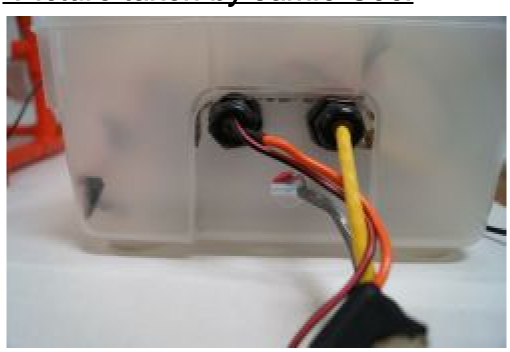
## Controls and Electronics

Our team opted to utilize the microcontroller-based system over the triggerfish or switch box-based system because once the code is written, by our programmer,  it is very easy to add or change the program to fit our needs. For example, other than a few slight mistakes, our engineers could easily have added the claw in a day or two to our existing design. The Stockbridge Underwater Robotics Team 2 took a quite a few more days to add the same functionality into their system. With our control system we gain unmatched controllability that sets us apart from other teams. We used dual bidirectional motor drivers (H-Bridge) because of its simple control interface, which would allow us to keep a lot of code written to control the motors that control the claw as well. Instead of using more than one Arduino Uno or use shift registers to gain more ports, we decided to upgrade to the Arduino Mega, which provides a massive increase in ports, so now the time to add another motor is dramatically reduced.



**Top View of Control Box-** This picture shows the inside of our control box.

*Picture taken by Jamie Cool*



**Side View of Control Box-** This picture shows how the wiring from our ROV runs to our control box.

*Picture taken by Jamie Cool*

## **Cameras**

Three cameras were added to our ROV at various angles so we could complete every task. It is, of course, necessary to have a camera angled toward the claw so we could see if we were close enough to pick up whatever objects the mission requires. The second camera is pointed toward the front so we can see where we are going while driving through the shipwreck. The third camera is on the back of the ROV angled downward, so when we drive over artifacts in certain missions, we can locate dates, ship types, or estimate the number of zebra mussels on the ship.

**Front View of Camera #1**

**Side View of Camera #1**

The first camera is located at the top of our ROV.

*Pictures taken by Jamie Cool*

**Front View of Camera #2**

**Side View of Camera #2**

The second camera is located on the inner frame of our ROV.

*Pictures taken by Jamie Cool*

**Front View of Camera #3**

**Side View of Camera #3**

The third camera is located on the back of our ROV.

*Pictures taken by Jamie Cool*

## Thrusters

If an ROV has propellers than a thruster is a necessity. These thrusters power our propellers, making them responsible for powering our entire ROV. We have six thrusters, with one for each propeller. Four thrusters were placed on the inside, one on each corner so it balances our ROV and gives us enough power to surface the artifacts. The other two were placed on the outside of the ROV because this allows us to make quicker tighter turns.

**Picture of Thruster-** This picture shows the position of our thruster.

*Picture taken by Rebecca Ensign*

## Propellers

Propellers are an essential part to any ROV. Our ROV utilizes six propellers. Two are placed on the outside of our ROV, and four are placed inside the framework. Without propellers, we wouldn't be able to drive our ROV. The propellers are programmed to the controller, which allows the propeller the drive the ROV up, down, forwards, backwards, and side-to-side.

**Propeller-** This picture shows propellers on the inner side of our frame.

*Picture taken by Rebecca Ensign*

## Shrouds

The engineers on our team knew that our ROV needed some type of cover over our propellers for safety reasons. We decided to use a PVC floor drain piece on all four propellers. The two shrouds on the outside of the ROV frame will prevent seaweed, coral, and the tether from getting caught in the propellers. The shrouds on all four propellers will protect any personnel’s fingers. Having these on our ROV will allow us and our ROV to work more quickly and efficiently under all circumstances.

**Shroud-** This picture shows how the shroud protects our propeller and any personnel around it.

*Picture taken by Jamie Cool*

## Conductivity Sensor

Our ROV has a conductivity probe, attached to a conductivity circuit which is able to send data back to our computer. Having a conductivity probe is important to incorporate on our ROV so we can test the conductivity of the water for clients.

## **Syringe**

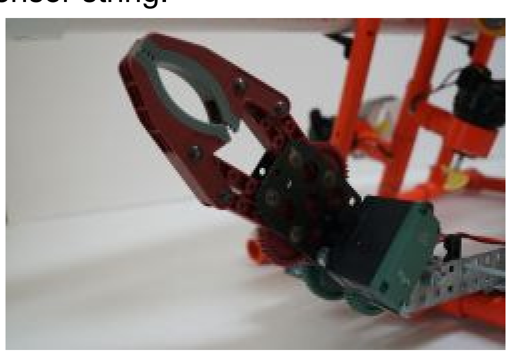
The syringe is our second payload tool. To efficiently retrieve samples of substances, such as agar, the engineers decided to attach a syringe to the ROV. There is a string attached to the handle of the syringe. Once the syringe is placed into the substance, the string will be pulled, sucking up the substance into the syringe. We knew the syringe was essential so we could complete this mission task.

**Syringe-** This picture shows the syringe that we will be using on our ROV to sample the agar.

**Picture taken by Jamie Cool*

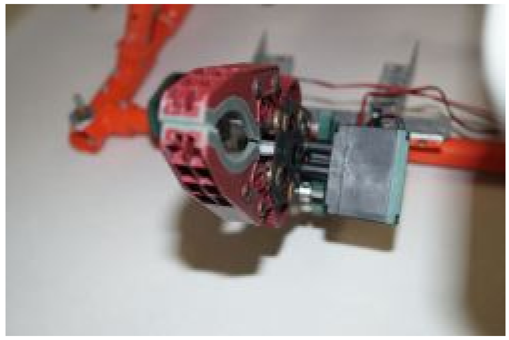
## **Claw**

The claw is one of our payload tools. Originally, we had a vertically mounted claw. At the MATE Regional Competition, our team had trouble completing the tasks that involved the claw, such as picking up bottles, moving the mast, and other tasks because we had limited mobility of the claw. Our team decided to then switch to a horizontally mounted rotating claw. We chose to include this feature because it would allow us to more efficiently complete our tasks. This way, we are able to have options on the way we pick things up, like the plate versus the sensor string.



**Side View of Claw-** This picture shows the side view of  our claw.

*Picture taken by Jamie Cool*



**Front View of Claw-** This picture contains the front view of our claw.

*Picture taken by Jamie Cool*

## Ballasts

We created two ballasts for our ROV out of two feet of PVC pipe. The two ballasts run across the top of each side on the ROV and were added to keep the ROV from sinking. However, the ballasts make our ROV is difficult to drive because it is too positively buoyant. With an ROV that is too positively buoyant, we wouldn't be able to explore a shipwreck because as soon as it would go underwater, it would just float back up. We adjusted to solve this problem by adding weights to the ROV to make it almost neutrally buoyant, so the ROV is easier to maneuver than when it is too positively buoyant. Also, we kept the ROV slightly positive so if something were to malfunction, it would float back to the surface.

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**Side View of Ballast-** This picture shows the placement of our ballast and a visual view of how long the ballasts are.

*Picture taken by Jamie Cool*

**Top View of Ballast-** This picture displays the top view of our ballasts.

*Picture taken by Jamie Cool*

## Tether

The word tether is a technical term for all of the wires involved in the ROV. As a team, we decided to put TechFlex over the wires to keep them together and avoid tangling. With a lot of wires taped together, the tether is easier to get tangled or snagged. To keep our tether in order, we bought a hose spool to hold the tether. The tether is sixty feet long so it is able to move through a shipwreck. We have a Tether Specialist who is in charge of manning the tether to put out more if the ROV needs to travel farther, or pull in more if it is coming closer and avoid getting our tether caught on objects.

**Tether-** This shows the TechFlex and where our tether is located on the ROV.

*Picture taken by Jamie Cool*

# Safety

At Stockbridge High School, we make safety our top priority for team, operators, and our ROV. As a team, we were always sure to read the warning labels to watch out for moving parts. We also made sure that the power was disconnected from any of power source before handling or working on the ROV. Despite our precautions, team faced some safety issues we had to find solutions to. A member on our team burnt her hair while soldering part of a triggerfish kit we were working on. We addressed this by requiring a dress code at Stockbridge High School. This includes tieing shoulder length hair back, wearing safety glasses, and having closed toed shoes. These guidelines helped minimize injuries and maximize safety.

The team didn't just set safety guidelines for the operators, but the ROV had several safety features as well. Our company applied shrouds to all four of the ROV's motors. This decreased the chance of being hit by a moving propeller and decreased the chance of getting the tether caught in the moving propeller. We filed down any jagged edges of cut PVC to make sure there weren't any hazardous sharp edges. This would prevent any unwanted cuts and snags, which could be problematic. Our company also made sure that we applied the proper fuse for our applications; we used a 20 amp fuse because each motor requires 5 amps. Below is our daily safety checklist.

## <u>Safety Checklist</u>

- ❏ Ensure that all operators with hair shoulder length or longer is tied back
- ❏ Make sure that all team members have proper safety gear on when appropriate
- ❏ Ensure that all team members have closed toed shoes
- ❏ Before handling the ROV, make sure all power supply is disconnected
- ❏ Ensure all electronics are far from the water
- ❏ All of the team members must have good and appropriate communication
- ❏ Before applying power to the ROV, make sure all team members are aware and clear
- ❏ Check that no wires are exposed
- ❏ Make sure that ROV is on cart so that moving parts don't hit the ground
- ❏ Check that the battery is correctly hooked up
- ❏ Make sure all controls are correctly set up in the program
- ❏ Ensure a team member is manning the tether

# Challenges We Overcame

Throughout the course of the year, our company faced many challenges. As a team, we decided to take the more complicated route and use the SeaMATE controller program. Our programmer, Philip, really struggled with programming the system to work with our payload tools. A troubleshooting technique we used was to unhook each component from the main system, and systematically determine the problem. We are a small school and don't have a pool to test our ROV in. Many days we would drive twenty-five miles to a nearby high school that has a pool to test our ROV. Quite a few times we would get there, set-up and realize that our programming system wasn't programmed correctly to work with our payload tools or a cable/board wasn't put together right. Our team corrected this problem by upgrading from the Arduino Uno to the Arduino Mega allowing us to have more output ports.

Another big obstacle our team had to overcome was having "newbies" on the team. Out of all five members on our team only one is a returning member. There are two girls on the team that basically came in blind knowing nothing about how the class ran, or how ROV's worked. They had to learn everything from the very basics of soldering. Two of our engineers were also new on the team and had to learn how a self paced classroom worked. Luckily, they had taken previous robotics classes so they knew somewhat about ROV's and programming.

# Skills Gained

### Time Management

The biggest lesson our team learned was time management. For students our age, time management is a hard concept to grasp. We are accustomed to parents or teachers laying out a strict time schedule for us when things need to be accomplished. Being in a project-based classroom, we quickly learned the difficulties of time management. We learned that we had to schedule our workload and time evenly and effectively. Otherwise, our team's work wouldn't be as successful as it could be due to feeling rushed and stressed. We did this by coming together as a team, figuring out our design for our ROV, and building the ROV in time so we had a decent amount of time to test our robot in the water.

### Flexibility

Another lesson our team learned was how to be flexible. Our team is split into two sub-teams: the marketing side and the engineering side. Sometimes members of the marketing team would have to help solder, make triggerfish kits, man the tether, or make any necessary adjustments to the ROV when the engineering leaders had their hands full with the Arduino control system. The engineering team would also step up and help the marketing team when due dates quickly approached us, such as the technical paper and the presentation. Because of our team's versatility, we were able to work more efficiently than if we strictly worked on the separate tasks we were responsible for.

### Prioritizing

Prioritizing is a difficult skill to gain and usually students our age realize what is most important when it is too late. Our team strives for success, and in order to have success, we need a plan of action with our most important tasks at the top of the list, such as tasks that have the nearest due date or the task that may take the most work and effort in order to complete. Prioritizing not only allows things to run smoothly, but it is also a great quality to have with a team that has so much to do with leadership.

# Future Improvements

In the future, our team plans on compacting our ROV further to make it easier to maneuver through our missions more efficiently and smoothly. Down-sizing our ROV will help us complete our missions faster and possibly helps us score more points. We also would have liked to construct our ROV sooner so that we are able to practice our missions for a longer period of time. This will help us feel more prepared when it comes to our performance during the competition. Our team decided that next time we would like to use a rotating claw so that it is easier to pick up objects for our missions.

We currently have a complete redesign of the control software to make it easier to change the settings, similar to what Spektrum has in its software. We were also planning to put in a config saver to save the current configs, but due to the simplicity of the controls we deemed it unnecessary for this year, and put it on our to do list for next year. Along with this software upgrade was a total overhaul of the current hardware to eliminate some, which would reduce the number possible failure points. Since we wanted to make our software as versatile as possible, we want to switch from being partially computer control to be entirely microcontroller or microprocessor based. The Beaglebone Black is currently what we want to switch to, but due to time constraints, we can't make this switch this year. Switching to the Beaglebone will also lower our end production costs, so we are able to be more efficient by running several of them for the same cost. We also hope to include two cameras dedicated to finding distances. He didn't have enough time to fully finish it before the event this year. This system would run into a powerful microprocessor, like the Beaglebone, and will perform relatively simple math to precisely get correct distances.

Our current tether isn't working as well as we hoped, so we plan to make the tether rotate more easily to improve performance.

# Reflections

## Rebecca

The most beneficial part of being on the competition team is the confidence I gained in my work. When I first started this class, I was nervous to voice my opinion and attack tasks that I thought I wasn't capable of accomplishing. I learned how to solder to make circuit boards for the triggerfish. I also learned how to efficiently make and wire a power distribution box. After completing these tasks successfully, I was more confident in my ability to work and succeed on my own. Furthermore, I have learned how to be independent and take initiative through this project.

## Andrew

My favorite and the most beneficial part of being on the competition team is that I'm able to work on being vocal in a group project. Usually I'm very quiet and laid-back, but on the competition team, I'm able to voice my opinion and have a more hands-on experience. For example, being able to wire, solder, build and design aspects of the ROV, I have learned from a teacher in our school, Mr.Watson. These jobs require tools I really didn't think I would ever use in my future profession, but I am able to now use them completely. Being on the competition team has given me a new outlook on real-world situations. Instead of just letting someone else do the task or fix the problem, I now step up and take charge by fixing the situation myself. That is a life skill most students don't really learn in normal classes, and that is something I love and will use everyday.

## Philip

Being on the competition team, gave me a chance to do what I love in school, programing and its related challenges. At our high school there is no other class that can match the joy being on this team can bring. Looking back over this year, I probably should have put more comments in my code to tell what it was doing. That would have allowed me to get the claw working faster than I did. If I did more programming in my spare time to get this done, I could have also completely the distance measurement tool in time for the competition.

## Jamie

As a first year member on the team, I feel that I have grown as a person and as a leader. I remember coming into class on the first day of school scared to death, thinking this class was going to be extremely hard because I had no prior knowledge of robots or marketing. It was hard, but the biggest thing I learned in this class is to adjust and go with the flow. These two qualities I learned have also helped me in many other aspects of my life. As a team, we had to adjust with each other's working habits and get along, which wasn't always easy. Overall, I feel that this class and competition was a great learning experience for everyone because this is the kind of stuff we will deal with everyday in the workplace.

## Mitch

This year will be my second year competing at the MATE Center ROV competition. What made this year different is my role as team leader. Unlike to my first year, I now have the responsibility of not only completing my own tasks, such as building the ROV, but making sure others accomplished his or her tasks as well. Along with leadership, I have learned how to be adaptable this year. Our team programmed a control system for our ROV completely differently from last year's, which posed many challenges, such as fixing the bugs in the program and adding our payload tools. By learning to always be adaptable to the situation, my team and I worked through these problems.

# References


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- DreamSpark
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- SlimDX
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- Avalon Dock
  http://avalondock.codeplex.com/

# Acknowledgements

**The team would like to thank anyone who supported us through the construction of our robot and the course of the class throughout the year.*

*Mr. Richards*- Our teacher, who was always there to answer questions and assist us when needed but always pushing us to do everything ourselves. Teaching us that failing is ok and that it takes more than one try to get something right. You just have to be patient.

*The MATE Center-* For donating supplies to us and always responding to emails when we had questions. Most of all we would like to thank them for the Triggerfish grant.

*Mr. Watson-* For always lending us his tools and allowing us to use his shop when we had to make parts for our ROV or test props.

*Chelsea Schools-* For allowing our team to generously use their pool for free during their open swim period.

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*Ms. Martell-* For revising this technical report.

*Chloe Hypes-* For revising and taking some pictures.